

-115 dB (W/m<sup>2</sup>) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane.

-115 + 0.5 (d-5) dB (W/m<sup>2</sup>) in any 1 MHz band for angles of arrival d (in degrees) between 5 and 25 degrees above the horizontal plane.

-105 dB (W/m<sup>2</sup>) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

These limits relate to the power flux density which would be obtained under assumed free-space propagation conditions.

15. A new Section 25.213 is added to read as follows:

§ 25.213 Inter-Service coordination requirements for the 1.6/2.4 GHz Mobile-Satellite Service.

(a) Protection of the radio astronomy service against interference from Mobile-Satellite Service systems in the 1610.6-1613.8 MHz band and 4990-5000 MHz band.

(1) Protection zones. All 1.6/2.4 GHz Mobile-Satellite Service systems shall be capable of determining the position of the transceivers accessing the space segment through either internal radiodetermination calculations or external sources such as LORAN-C or the Global Positioning System. During periods of radio astronomy observations, land mobile earth stations shall not cause harmful interference in the 1610.6-1613.8 MHz frequency band when located within the geographic protection zones defined by the radio observatory coordinates and separation distances as follows:

(i) Within a 160 km radius of the following radio astronomy sites:

Observatory	Latitude (DMS)	Longitude (DMS)
Arecibo, PR	18 20 46	66 45 11
Green Bank Telescope, WV	38 25 59	79 50 24
	38 26 08	79 49 42
Very Large Array, NM	34 04 43	107 37 04
Owens Valley, CA	37 13 54	118 17 36
Ohio State, OH	40 15 06	83 02 54

(ii) Within a 50 km radius of the following sites:

Observatory	Latitude (DMS)	Longitude (DMS)
Pile Town, NM	34 18 04	108 07 07
Los Alamos, NM	35 46 30	106 14 42
Kitt Peak, AZ	31 57 22	111 36 42
Ft. Davis, TX	30 38 06	103 56 39
N. Liberty, LA	41 46 17	91 34 26
Brewster, WA	48 07 53	119 40 55
Owens Valley, CA	37 13 54	118 16 34
St. Croix, VI	17 45 31	64 35 03
Mauna Kea, HI	19 48 16	155 27 29
Hancock, NH	42 56 01	71 59 12

(iii) For airborne earth stations operating in the 1610.6-1613.8 MHz frequency band, the separation distance shall be the larger of the distance specified in subparagraph (i) or (ii) of this paragraph, as appropriate, or the distance, d, as given by the formula:

$$d \text{ (km)} = 4.1 \text{ square root of } (h)$$

where h is the altitude of the aircraft in meters above ground level.

(iv) A smaller geographic protection zone may be used in lieu of the areas specified in subparagraphs (i), (ii), and (iii) of this paragraph if agreed by the Mobile-Satellite Service licensee and the Electromagnetic Spectrum Management Unit (ESMU), National Science Foundation, Washington, D.C. upon a showing by the Mobile-Satellite Service licensee that the operation of a mobile earth station will not cause harmful interference to a radio astronomy observatory during periods of observation.

(v) The ESMU shall notify Mobile-Satellite Service space station licensees authorized to operate in the 1610-1626.5 MHz band of periods of radio astronomy observations. The mobile-satellite system shall be capable of terminating or otherwise controlling operations in this band within the first position fix of the mobile terminal prior to transmission or as soon as practicable after entering the protection zone to prevent harmful interference.

(vi) A beacon-actuated protection zone may be used in lieu of fixed protection zones in the 1610.6-1613.8 MHz band if a coordination agreement is reached between a

mobile satellite system licensee and the EMSU on the specifics of beacon operations.

(vii) Additional radio astronomy sites, not located within 100 miles of the 100 most populous urbanized areas as defined by the United States Census Bureau at the time, may be afforded similar protection one year after notice to the mobile-satellite system licensee and the issuance of a public notice by the Commission.

(2) Mobile-satellite service space stations transmitting in the 1613.8-1626.5 MHz band shall implement such coordination techniques as necessary to avoid harmful interference to the facilities listed in paragraphs (a)(1)(i) and (a)(1)(ii) of this section during periods of observation.

(3) Coordination between MSS/RDSS operators and ESMU shall be undertaken to avoid scheduling radio astronomy observations during peak MSS/RDSS traffic periods to the greatest extent practicable.

(4) Mobile-Satellite Service space stations operating in the 2483.5-2500 MHz frequency band shall limit spurious emission levels in the 4990-5000 MHz band so as not to exceed -241 dB(W/m<sup>2</sup>/Hz) at the surface of the Earth.

(b) Protection of the radionavigation-satellite service operating in the 1559-1610 MHz band. Mobile earth stations operating in the 1610-1626.5 MHz band shall limit out-of-band emissions in the 1574.397-1576.443 MHz band so as not to exceed an e.i.r.p. density level of -70 dB (W/MHz) average over any 20 ms period. The e.i.r.p. of any discrete spurious emission (i.e., bandwidth less than 600 Hz) in the 1574.397-1576.443 MHz band shall not exceed -80 dBW.

(c) Protection of aeronautical radionavigation systems operating pursuant to International Radio Regulation RR 732.

(1) In the event that the e.i.r.p. density levels of mobile-satellite earth stations transmitting in the 1610-1626.5 MHz band exceed -15 dB (W/4kHz) on frequencies being used by systems operating in accordance with International Radio Regulation RR 732, or exceed -3 dB (W/4kHz) on frequencies that are not so being used, such earth stations shall coordinate their operations with systems operating in accordance with RR 732, and shall implement such coordination techniques as to avoid harmful interference to such systems. Pursuant to RR 731E and RR 731F, all mobile-satellite operations in the 1610-1626.5 MHz band (both Earth-to-space and space-to-Earth) must be coordinated with systems operating pursuant to RR 732. Such mobile-satellite stations shall not cause harmful interference to, or claim protection from, stations in the aeronautical radio-

navigation service and stations operating pursuant to RR 732.

(2) Airborne 1.6/2.4 Mobile-Satellite Service earth stations shall not operate on civil aircraft unless the earth station has a direct physical connection to the aircraft cockpit and/or cabin communication system.

(3) Mobile-satellite space stations whose space-to-Earth links operate in the 1613.8-1626.5 MHz band shall not exceed a power flux density level at the Earth's surface of  $-141.5 \text{ dBW/m}^2\text{-4 KHz}$  in the frequencies used by systems operating in accordance with International Radio Regulation RR 732.

(d) Protection from fixed stations operating pursuant to International Radio Regulation RR 730. Pursuant to RR 731E, and subject to Resolution 46 (formerly COM5/8), all mobile-satellite operations in the 1610-1626.5 MHz band (both Earth-to-space and space-to-Earth) must be coordinated with systems operating pursuant to RR 730. All such mobile-satellite stations shall not cause harmful interference to, or claim protection from, stations in the fixed service operating pursuant to RR 730.

16. A new Section 25.278 is added to read as follows:

§ 25.278 Additional coordination obligations for non-geostationary and geostationary satellite systems in frequencies allocated to the Fixed-Satellite Service.

Licensees of non-geostationary satellite systems that use frequency bands allocated to the Fixed-Satellite Service for their feeder link operations shall coordinate their operations with licensees of geostationary Fixed-Satellite Service systems licensed by the Commission for operation in the same frequency bands. Licensees of geostationary Fixed-Satellite Service systems in the frequency bands that are licensed to non-geostationary satellite systems for feeder link operations shall coordinate their operations with the licensees of such non-geostationary satellite systems.

17. A new section 25.279 Inter-satellite service.

§ 25.279 Inter-satellite service

(1) Any non-geostationary satellite communicating with other space stations may use frequencies in the inter-satellite service as indicated in § 2.106. Such operation or use does not preclude the use of other frequencies for such purposes as provided for in several service definitions, e.g., FSS. The technical details of the proposed inter-satellite link shall be provided in accordance with § 25.114(c).

(2) Operating conditions. In order to ensure compatible operations with authorized users in the frequency bands to be utilized for operations in the inter-satellite service, these inter-satellite service systems must operate in accordance with the conditions specified in this section.

(a) Coordination requirements with federal government users.

(i) In frequency bands allocated for use by the inter-satellite service that are also authorized for use by agencies of the federal government, the federal use of frequencies in the inter-satellite service frequency bands is under the regulatory jurisdiction of the National Telecommunications and Information Administration (NTIA).

(ii) The Commission will use its existing procedures to reach agreement with NTIA to achieve compatible operations between federal government users under the jurisdiction of NTIA and inter-satellite service systems through frequency assignment and coordination practice established by NTIA and the Interdepartment Radio Advisory Committee (IRAC). In order to facilitate such frequency assignment and coordination, applicants shall provide the Commission with sufficient information to evaluate electromagnetic compatibility with the federal government users of the spectrum, and any additional information requested by the Commission. As part of the coordination process, applicants shall show that they will not cause unacceptable interference to authorized federal government users, based upon existing system information provided by the government. The frequency assignment and coordination of the satellite system shall be completed prior to grant of construction authorization.

(b) Coordination among inter-satellite service systems. Applicants for authority to establish inter-satellite service are encouraged to coordinate their proposed frequency usage with existing permittees and licensees in the inter-satellite service whose facilities could be affected by the new proposal in terms of frequency interference or restricted system capacity. All affected applicants, permittees, and licensees, shall at the direction of the Commission, cooperate fully and make every reasonable effort to resolve technical problems and conflicts that may inhibit effective and efficient use of the radio spectrum; however, the permittee or licensee being coordinated with is not obligated to suggest changes or re-engineer an applicant's proposal in cases involving conflicts.

18. The authority citation for Part 94 continues to read as follows:

AUTHORITY: Secs. 4, 303, 48 Stat., as amended, 1066, 1082;  
47 U.S.C. 154, 303 unless otherwise noted.

19. Section 94.61 is amended by revising paragraph (b)(4) to read as follows:

§ 94.61 Applicability.

\* \* \* \* \*

(b)(4) Frequencies in this band are shared with mobile and radiolocation stations in other services, and must accept harmful interference that may be experienced from operations of industrial, scientific, or medical (ISM) equipment operating on 2450 MHz. In the 2483.5-2500 MHz band, no applications for new stations or modifications to existing stations to increase the number of transmitters will be accepted. Existing licensees as of July 25, 1985, are grandfathered and their operation is co-primary with the Radiodetermination Satellite Service and Mobile-Satellite Service. However, all grandfathered temporary fixed licensees are required to notify directly each Radiodetermination Satellite Service and Mobile-Satellite Service licensees concerning present and proposed locations of operations.



*Final Report*

# **The Economic Impacts of Low Earth Orbit Satellite Systems**



**SUBMITTED TO**  
Motorola Satellite  
Communications, Inc.

**SUBMITTED BY**  
Nathan Associates Inc.

May 4, 1994



# Contents

I. Introduction	1
II. Big LEO Operations	1
III. Demand for Big LEO Services	3
IV. Income and Employment Impacts	5
V. Other Economic Effects of Big LEOs	9

## **I. INTRODUCTION**

In 1990 and 1991, several entities filed applications with the Federal Communications Commission (FCC) for authority to construct and operate low earth orbit (LEO) satellite systems to offer an array of voice, data, message, and position locating mobile communications services. The five proposed Big LEO systems are the IRIDIUM<sup>TM/SM</sup> system of Motorola Satellite Communications, Inc.; LORAL/Qualcomm's GLOBALSTAR; ARIES of Constellation Communications, Inc.; Ellipsat Corporation's ELLIPSO; and Odyssey of TRW, Inc.

The hallmark of each LEO system is a cellular-like mobile telephone service. Each of the Big LEOs will be interconnected to the public switched telephone network (PSTN), cellular, and other terrestrial communications systems. Consequently, within the geographic coverage of each Big LEO system, a subscriber will be able to call or be called from any other fixed or mobile telephone.

In this report, Nathan Associates Inc., an economic and management consulting firm based in Arlington, Virginia, identifies, assesses, and describes the economic impacts and other effects of establishing Big LEO systems on behalf of Motorola Satellite Communications, Inc. (Motorola). Nathan Associates has several years of experience analyzing the economics of telecommunication markets. Nathan Associates has forecast the demand for cellular telephone service in over 100 metropolitan markets and the demand for mobile satellite services in the United States in the FCC proceeding in which American Mobile Satellite Corporation (AMSC) was licensed to offer such services.

## **II. BIG LEO OPERATIONS**

As a group, Big LEOs will provide seamless global coverage, with a wide array of mobile communications, including voice telephone, paging and messaging, facsimile and data, and navigation and position location services. Although technically capable of being used in place of terrestrial communications systems, Big LEOs are expected to be complementary to existing terrestrial systems and to focus on satisfying unserved and underserved communications needs.

All Big LEOs will be interconnected to fixed, cellular, and other terrestrial communications systems. Several will have dual mode subscriber units which will allow the subscriber (1) to use cellular or other terrestrial communications when the call can be connected through terrestrial systems; and (2) to switch over to a Big LEO, such as the IRIDIUM system, when one end of the call is not covered by terrestrial systems. Cellular subscribers that also subscribe to the IRIDIUM system and obtain a dual mode telephone would extend their roaming ability to the entire globe. When in the home

service area or other areas served by other cellular systems, the subscriber could use the less expensive terrestrial systems. When roaming in areas not covered by terrestrial systems, the subscriber could simply switch to the IRIDIUM system mode to be in voice contact with any other telephone in the world.

By filling in the coverage gaps of terrestrial systems around the world, and by interconnecting satellite and terrestrial systems, the IRIDIUM system and the other Big LEOs will help complete the information superhighway. Subscribers will be able to enjoy fast, high-quality voice and data communications on this superhighway, regardless of where the subscribers reside, work, or travel. By complementing rather than competing with cellular and other terrestrial systems, Big LEOs will increase, rather than detract from, the demand for terrestrial system service. After all, one end of most calls on a Big LEO system will be to or from a terrestrial telephone. Thus, both terrestrial systems and a Big LEO system will be needed to complete many calls.

In addition, the IRIDIUM system and the other Big LEOs will serve areas that currently do not have access to mobile services. Even in advanced countries like the United States there are rural areas that are so sparsely populated that it is not economical to provide mobile communications infrastructure. Cellular telephone service is not accessible in the United States to more than 7 million people.<sup>1</sup>

Finally, the IRIDIUM system and other Big LEOs will extend the information superhighway to developing countries where terrestrial and mobile telephone services are limited, and, more important, the IRIDIUM system and other Big LEOs will be the least expensive way of providing access to telephone systems in these countries. China, India, Indonesia, Nigeria, Pakistan, Bangladesh, the Philippines, Ethiopia, and Myanmar (formerly Burma) together account for one-half of the world's population. Yet the people in these countries are served by no more than one telephone line per 100 people. In contrast, U.S. and Canadian citizens are served by 51 and 57 telephone lines per 100 people, respectively.<sup>2</sup> Based on the cost of providing the IRIDIUM system infrastructure worldwide, the people in these nine developing countries can gain access to communication services comparable to those found in the United States at a cost that will be no more than \$5.11 per line, an amount much less than the cost of providing wireline service.<sup>3</sup>

---

<sup>1</sup>Based on information from the Cellular Telephone Industry Association.

<sup>2</sup>Population data are from *World Development Report 1993*, World Bank, and telephone access information is from *Statistical Abstract of the United States: 1993*, U.S. Department of Commerce.

<sup>3</sup>The population of these nine developing countries is 2,681.2 million. Currently, these people are served by no more than 26.812 million telephone lines (no more than one line per 100 people). To raise this service to a level comparable to that found in the United States (51 lines per 100 people) would require the addition of 1,341 million lines ( $0.51 \times 2,681.2 \text{ million} - 26.812 \text{ million}$ ). As discussed later in this report, the cost of providing the IRIDIUM system infrastructure (the initial constellation of satellites, the gateways, and the first replacement

### III. DEMAND FOR BIG LEO SERVICES

International business travelers in remote parts of advanced countries and throughout much of the developing world, including eastern Europe and the former Soviet Union, will be the most frequent users of the IRIDIUM system and other Big LEOs. Law enforcement, emergency respondents, and other public safety agencies, as well as other government entities at the national, state, and local levels, will also subscribe to the IRIDIUM system or other Big LEO services. Big LEOs, unlike terrestrial systems, are essentially disaster proof. They function during earthquakes, hurricanes, floods, tornadoes, fires, and other disasters. In some remote areas, satellite communication will be the only type available to government or other users.

Aeronautical demand for telephone service will also be significant. Because Big LEOs can provide superior geographic coverage and lower cost receivers than terrestrial based or geosynchronous satellite systems, Big LEOs will capture much of the commercial aircraft market. General and business aviation will also gradually switch to Big LEO service.

Recreational and leisure activities are another source of demand for Big LEO service. Many will want to equip recreational vehicles, which are often driven through and to remote areas, with Big LEO mobile telephones. Similarly, many of those owning or operating pleasure boats will want them equipped with the superior Big LEO mobile telephones.

Ocean-going commercial ships now usually use the geosynchronous satellite service of the International Maritime Satellite Organization (Inmarsat), and most ships have Inmarsat transmitter/receivers in their radio rooms. Because ocean shipping is reasonably well served by Inmarsat, the IRIDIUM system and the other Big LEOs are not expected to focus on international shipping. However, the IRIDIUM system will be marketed to companies operating ships in coastal waterways, rivers, canals, and lakes, when they lack affordable, reliable, or continuous communications service.

Other industries will also use Big LEO services. Construction and oil and mineral extraction companies often operate in remote areas. Big LEOs will make global paging service a reality. International business travelers will be the most common users of the paging services of the Big LEOs.

The developing countries of the world will also constitute a large proportion of the demand for Big LEO service. As stated above, in some parts of the developing world, even fixed telephone service is non-existent, and in much of the rest of the developing world, telephone and other communications are

---

satellites) worldwide will be \$6.85 billion. Therefore, assuming the IRIDIUM system were dedicated to these nine developing countries, the cost per additional line in these countries will be no more than \$5.11 ( $\$6.85 \text{ billion} \div 1.341 \text{ billion lines}$ ).

very inadequate. Businesses in the developing countries especially need the reliable service Big LEOs will provide.

As shown below, demand for Big LEO services will be sufficient to support more than one Big LEO system. Across all of the market segments, Motorola estimates that the demand for the voice, data, and RDSS of the Big LEOs by 2001 will be almost 1.4 million U.S. subscribers and over 6 million subscribers worldwide.<sup>4</sup> While some of this demand comes from users who will switch from existing services to one of the superior Big LEO services, most of the demand is currently unmet. The Big LEOs will serve regions of the world and user groups that are now largely unserved.

<i>Market Segment</i>	<i>Number of Big LEO Subscribers in 2001</i>		
	<i>United States</i>	<i>Other Countries</i>	<i>Total</i>
Voice and data services:			
International business travelers	30,000	120,000	150,000
National governments	20,000	400,000	420,000
State or provincial governments	8,000	160,000	168,000
Local governments	28,000	560,000	588,000
Commercial aircraft	2,500	2,500	5,000
Private business aircraft	7,000	2,000	9,000
General aviation	60,000	40,000	100,000
Recreational vehicles	400,000	100,000	500,000
Luxury pleasure boats	210,000	210,000	420,000
Coastal and inland waterway shipping	6,000	40,000	46,000
Construction and extraction industries	5,000	15,000	20,000
Public telephones in developing countries	--	300,000	300,000
Business users in developing countries	--	300,000	300,000
Total voice and data	776,500	2,249,500	3,026,000
RDSS:			
Trucking	310,000	1,240,000	1,550,000
Global paging	300,000	1,200,000	1,500,000
Total RDSS	610,000	2,440,000	3,050,000
Grand total	1,386,500	4,689,500	6,076,000

<sup>4</sup>See the Motorola application for IRIDIUM before the Federal Communications Commission, December 1990, Table III-1, p. 34.

#### **IV. INCOME AND EMPLOYMENT IMPACTS**

Beyond providing new services that will satisfy sizable unmet demand, Big LEOs will generate substantial income and employment. The development and eventual operation of any Big LEOs is a substantial undertaking involving a variety of economic activities, including:

- (1) Further research and development
- (2) Manufacture of satellite components
- (3) Assembly of satellites
- (4) Launch of satellites
- (5) Manufacture of earth station or gateway equipment
- (6) Construction and installation of gateways
- (7) Manufacture of subscriber units
- (8) Operation and maintenance of space segments, including the manufacture and launch of replacement satellites
- (9) Operations and maintenance of gateways
- (10) Wholesale and retail distribution of subscriber units and service

As explained in more detail below, the contribution to national income and the creation of jobs by the IRIDIUM system alone will be substantial.

##### **A. The IRIDIUM System's Economic Impacts**

Nathan Associates estimates that by 2002, the U.S. employment impact of the IRIDIUM system will total approximately 241,000 jobs-years and the household earnings impact will total \$6.7 billion.<sup>5</sup> The economic activity associated with the IRIDIUM system in the years beyond 2002 will continue to support employment and generate earnings impacts in the U.S. economy.

---

<sup>5</sup>As explained in detail below, these estimates include direct, indirect, and induced impacts. Nathan Associates previously estimated direct employment impacts of the IRIDIUM system based, initially, on an estimated \$5 billion expenditure and sales per employee per year of \$116,959 (see "Inmarsat's Project 21 and U.S. Policy," June 5, 1992) and, later, on an estimated \$2.88 billion expenditure on the initial constellation of satellites and sales per employee per year of \$118,866 (see "Entry and Competition in the Emerging Market for Global Mobile Handheld Telephone Service," December 22, 1993). Neither of these estimates is comparable to the employment estimate presented in this report. The 241,000 jobs estimated here include direct, indirect, and induced employment impacts of a total expenditure of \$6.83 billion through 2002. Moreover, as explained below, the estimate is derived from final demand multipliers of the RIMS II BEA model; it is not derived from a ratio of sales per employee.

Significant U.S. economic impacts of the IRIDIUM system will result from expenditures on the:

- Manufacture and launch of the initial constellation of satellites,
- Manufacture and distribution of user units sold to system subscribers,
- Development and construction of the IRIDIUM system gateways or earth stations, and
- Manufacture and launch of replacement satellites.

Additional impacts will result from expenditures made on the day-to-day operation and maintenance of the system and the provision of communication services. These expenditures and their additional impacts are not included in this analysis.

### ***1. Methodology and Data***

Economic impacts result from the ripple effect created by industries buying from and selling to each other. The production of output (goods and services) by any one industry requires the use of or consumption of output of numerous other industries. As a result, when the demand for the output of a particular industry changes, the ripple effect creates changes in the demand for and production of output of other industries. For example, the provision of IRIDIUM system communication services will use satellites produced by U.S. manufacturing industries. The satellite manufacturers will use U.S. electronic components and numerous other items and materials produced by other U.S. industries. Hence, investments in satellites result in expenditures on other products and services. By the time the ripple subsides, total output has changed by a multiple of the initial change.

The magnitude of U.S. economic impact of any expenditure depends primarily on two factors: the amount of expenditure and the extent to which the expenditure is recycled through the U.S. economy. The larger the expenditure, the larger the impact; and, for any given amount expended, the larger the proportion of expenditure that remains in the U.S. economy, the larger the impact. Because the IRIDIUM system will consist largely of products developed, manufactured, operated, and maintained by U.S. workers, its U.S. economic impacts will be greater than the impacts of a system of components manufactured and managed abroad.

Two types of data are used to estimate economic impacts: expenditure data provided by Motorola and economic impact multipliers generated by the Regional Input-Output Modeling System (RIMS II) of the Bureau of Economic Analysis (BEA), U.S. Department of Commerce. At this time, estimates of the magnitude of expenditures, the timing of the expenditures, and the distribution of expenditures by industry are not precise. Therefore, the estimates presented here are best considered to be "order of magnitude" measures.

Estimates of the IRIDIUM system expenditures to be made in the U.S. economy are listed below:

- \$2.88 billion for investment in initial constellation of satellites between 1994 and 1998 (nearly 85 percent of the \$3.37 billion in contracts awarded for the development, construction, and launch of the IRIDIUM space segment system);
- \$600 million for U.S. subscribers' purchases of U.S. manufactured terminal units through 2002
  - 64.1 percent in producer's prices,
  - 0.2 percent in transportation margins,
  - 2.9 percent in wholesale margins, and
  - 32.8 percent in retail margins;
- \$610 million for investment in gateways through 2000, including
  - \$160 million in design and development,
  - Out of a total of \$200 million for purchase of gateway components, \$150 million for purchase of U.S. manufactured components, and
  - \$300 million for manufacture, construction, and installation; and
- \$2.74 billion for investment in replacement satellites between 1998 and 2002.

The RIMS II multipliers used in this analysis measure the total impact of a change in the final demand for the output of a given industry. The total impact consists of three effects: the direct effect of the industry itself, the indirect effect of all other industries in the economy, and the induced effect of household consumption triggered by changes in household earnings from employment. Employment multipliers measure the total change in the number of jobs in all industries for each additional \$1 million of a given industry's output delivered to final demand. Household earnings multipliers measure the total dollar change in earnings of households employed in all industries for each additional dollar of a given industry's output delivered to final demand. Final demand for output consists of demand by households for personal consumption of goods and services (for example, sales of the IRIDIUM system user units to households), business investment (for example, investment in the initial constellation of satellites, the gateways, and the replacement satellites), government consumption, and exports.

The industries modeled here include the radio and TV broadcasting and communications equipment manufacturing industry (for all investment expenditures and for consumption of unit devices measured in producer's prices), the transportation industry (for the transportation margin on consumption of unit devices), the wholesale trade industry (for the wholesale margin on consumption of user units), and the retail trade industry (for the retail margin on consumption of user units). Employment and earnings multipliers for each of these industries are listed below:



- Radio and TV broadcasting and communications equipment manufacturing
  - Employment: 34.6 jobs per \$1 million of output delivered to final demand
  - Earnings: \$0.9794 per dollar of output delivered to final demand
- Transportation
  - Employment: 40.7 jobs per \$1 million of output delivered to final demand
  - Earnings: \$0.9803 per dollar of output delivered to final demand
- Wholesale trade
  - Employment: 34.1 jobs per \$1 million of output delivered to final demand
  - Earnings: \$0.8611 per dollar of output delivered to final demand
- Retail trade
  - Employment: 58.1 jobs per \$1 million of output delivered to final demand
  - Earnings: \$1.0456 per dollar of output delivered to final demand

## ***2. Employment Impacts***

In total, the U.S. employment impact of the IRIDIUM system through 2002 will be nearly 241,000 job-years. The employment impact consists of

- 99,600 job-years associated with the investment in the initial constellation of the IRIDIUM system satellites through 1998,
- 25,400 job-years associated with subscribers' demand for user units through 2002,
- 21,100 job-years associated with investment in U.S. gateways through 2000, and
- 94,800 job-years associated with investment in replacement satellites through 2002.

## ***3. Earnings Impacts***

In total, the U.S. household earnings impact of the IRIDIUM system through 2002 will be \$6.7 billion. The earnings impact consists of

- \$2,821 million associated with the investment in the initial constellation of the IRIDIUM system satellites through 1998,
- \$599 million associated with subscribers' demand for user units through 2002,
- \$597 million associated with investment in U.S. gateways through 2000, and
- \$2,684 million associated with investment in replacement satellites through 2002.

## **B. Economic Impacts of Other Big LEOs**

Although Nathan Associates has not had access to detailed financial information about other Big LEOs, the development of any Big LEO system will require sizable capital expenditures. These investments will have significant impacts on U.S. employment and earnings. Although the economic impacts of the

IRIDIUM system will be greater than the impacts of any other proposed Big LEO system because the IRIDIUM system will comprise more satellites and provide more extensive (seamless global) coverage, each Big LEO requires investments on a scale that will result in significant impacts on the U.S. economy. The development of only one or two additional Big LEOs would add greatly to the U.S. employment and earnings impacts of the IRIDIUM system.

## **V. OTHER ECONOMIC EFFECTS OF BIG LEOS**

The United States is the undisputed world leader in the development of space technology. Development and operation of U.S.-based Big LEOs will help maintain U.S. technological leadership. With its LEO design, intersatellite communication, dual mode subscriber units, and other unique aspects, the IRIDIUM system is already an array of technological innovations. As the IRIDIUM system and other Big LEOs evolve and become operational, the solutions to unanticipated technical problems and the satisfaction of new subscriber needs will undoubtedly lead to further innovations.

The enhanced services of the IRIDIUM system and other Big LEOs and the provision of Big LEO services to previously unserved or underserved areas both in the United States and abroad will benefit economies and people throughout the world. Telecommunication innovations free up resources that can be used more efficiently elsewhere. As a result, telecommunication production efficiencies increase; real service prices decline; end-users become more productive, especially in service sectors that rely heavily on the flow of information; and industries and economies become more competitive.<sup>6</sup> In the United States, 90 percent of the jobs created during the past decade were information related.<sup>7</sup> Investments in telecommunications infrastructures are essential to facilitate the flow of information and spur continuing economic growth and development. As recently stated by Reed E. Hundt, Chairman of the Federal Communications Commission:<sup>8</sup>

An efficient communications system means an end to isolation. Where people are in communication there is a possibility of health care, of education, of democracy, of economic growth, of sustainable development.

Communication by telephone is not a luxury, but is the key to economic growth and the essential condition to full participation in the modern world.

---

<sup>6</sup>See Francis J. Cronin, Paul Hebert, and Elisabeth Colleran, "Linking Telecommunications and Economic Competitiveness," *Telephony*, Vol. 223, No. 10, Sept. 7, 1992, pp. 38-42.

<sup>7</sup>See Patricia M. McGovern and Paul Hebert, "Telecommunications and Economic Development," *Telephony*, Nov. 2, 1992.

<sup>8</sup>See Reed E. Hundt, Chairman, Federal Communications Commission, Speech to World Telecommunication Development Conference, March 22, 1994.

The development, manufacture, operation, and maintenance of the IRIDIUM system and of other Big LEO systems will have important and substantial impacts on the U.S. and world economies. In addition to the IRIDIUM system's economic impacts of nearly one-quarter of one million job-years and \$6.7 billion in household earnings in the United States alone, the IRIDIUM system and other Big LEO systems will spur economic development around the world, enhance economic productivity, and blaze a worldwide trail for the information superhighway.

## CERTIFICATE

I hereby certify that I am the qualified person responsible for preparation of the report "The Economic Impact of Low Earth Orbit Satellite Systems," that I have either prepared or reviewed the information submitted in this report, and that it is complete and accurate to the best of my knowledge and belief.

Gary L. French

Title: Vice President  
Nathan Associates Incorporated

Date: May 4, 1994



Reed E. Hundt, Chairman  
Federal Communications Commission  
Speech to World Telecommunication  
Development Conference  
March 22, 1994

The purpose of this first Development Conference of the International Telecommunication Union should be to end the solitude that inattention and poverty have meted out to millions of people in this world.

As our country's Vice-President did yesterday, I would like to begin by quoting a great writer:

"Many years later, as he faced the firing squad, Colonel Aureliano Buendia was to remember that distant afternoon when his father took him to discover ice."

That is, of course, the first line of Gabriel Garcia Marquez' One Hundred Years of Solitude, the most influential Spanish language novel since Don Quixote. The book is the story of the mythical town of Macondo, a place isolated from its nation, cut off from the world.

We gather here in Buenos Aires, at this first conference of telecommunications regulators called for the purpose of discussing development, because we know that much of the world lives in towns like Macondo, isolated from their country, hundreds of years apart from modern technology, cut off from communication with the world.

Just as in Garcia Marquez' novel "ice" was an object of infinite rarity and preciousness in the tropical climate of the fictional Macondo, so the telephone is today a rare thing in thousands of communities.

More than half the people on our planet have never made a telephone call. Less than a third have ready access to telephones. In the world's low income countries, there is less than one telephone per 100 people.

Where there are no telephones, there is isolation.

An efficient communications system means an end to isolation. Where people are in communication there is a possibility of health care, of education, of democracy, of economic growth, of sustainable development.

Telecommunications can hasten the arrival of participatory democracy. As we meet, South Africa is using telecommunications to inform people about how to vote, how to exercise their democratic rights.

Telecommunications can improve health care. In Guyana, rural health workers improve the quality of health care by discussing diagnoses in conference calls with physicians in the capital of Georgetown.

Communication by telephone is not a luxury, but is the key to economic growth and the essential condition to full participation in the modern world.

For that reason, in my job as Chairman of the Federal Communications Commission I and my colleagues have emphasized two themes in our decisionmaking: economic growth and access.

First, we attempt to increase economic growth through our decisions. Communication makes economies grow, domestically and internationally. In our country the communications and information sector will be one-sixth of the total economy by the year 1997.

Tokyo is one of the major financial, commercial and industrial centers of the world. It is no coincidence that Tokyo has more than 66 lines per 100 people, and has the highest ratio of fax machines to people. Japan's communications infrastructure is a key reason for the 10 fold increase in its GNP during the last 40 years.

But there are fewer telephones in the whole of Africa than in Tokyo. This marks not only Japan's accomplishment but also the tragic shortcomings of development elsewhere.

Another measure of the uneven state of communications development is the pattern of international fiber-optic cables and satellite services. Most serve the Northern Hemisphere, and extend East-West. The Southern Hemisphere is grossly underserved.

As a consequence, a phone call from the Ivory Coast to Nigeria -- only 800 miles away -- often is routed through London, then Paris, and finally to Abidjan. The 6000 mile route vastly increases the cost of the call. In the information age, the lack of an effective infrastructure frustrates sustainable development.

The second theme of our decisionmaking at the FCC is access. This means access of our people to each other and access of businesses to customers, whether they want to sell soap or software.

The objectives of economic growth and access are achievable in our country and in every country because of breakthroughs of invention and entrepreneurship.

As an example, AT&T is building in Indonesia wireline networks employing state of the art fiber optic technology. Advanced digital switching is being installed in Bangalore, India. A nationwide cellular system is being deployed here in Argentina.

Satellite technology offers opportunities to build a global, seamless connection among all networks. There is no more compelling case for governmental cooperation and parallel regulation than that presented by satellite providers. They seek to serve the globe, and all countries should cooperate by opening markets to their services.

However, in order to make the most out of modern technology and entrepreneurship, all countries must not only develop adequate infrastructures, they must adopt appropriate regulatory regimes. As Vice-President Gore said yesterday, the key principles of regulation should include:

- First, reliance on private investment.

As a corollary, the private sector must be guaranteed a reasonable opportunity to obtain a fair return on investment. And to maximize the investment incentive, state-owned telecommunications facilities should be privatized.

- Second, competition instead of monopolies.

Competition will lead to pricing toward cost, and therefore will hasten the development of universally available communications networks.

Competition increases innovation, reliable service, and economic growth. But competition must be fair. We aggressively seek in our domestic markets to eliminate cross subsidies and discriminatory access. These policies should be applied internationally.

The competitive model also dictates that international accounting rates and collection charges should be cost-based. Lower prices for telecommunications service dramatically increase demand. This in turn creates more revenues, extending and sustaining world communications networks.

We believe that all countries will benefit from reducing accounting rates and calling prices to appropriate cost-based levels, because then networks will be used more efficiently and domestic businesses will be more competitive.

- Third, a flexible regulatory framework.

Regulators must have the freedom to accommodate evolving technological changes and to ensure that regulations are responsive to market demands, while safeguarding the public interest.

- Fourth, open access, interconnection and interoperability.



If all the members of the ITU do not work together to develop open, interconnected and interoperable networks, the vision of a Global Information Infrastructure will give way to isolated, fragmented systems. These have less value in all respects than globally interconnected systems.

It is especially important not to permit a monopolistic incumbent carrier to block competition through financial and technical barriers. Regulators should issue effective interconnection rules and fair pricing policies.

- Finally, universal service.

As President Menem said yesterday, we have a moral duty to find a way to link people to everyone in their country, and all countries should be linked to the Global Information Infrastructure.

I hope all of you will embrace this commitment to the full implementation of universal service.

Achieving it will require in each country a careful assessment of economic efficiencies, technical capabilities and social benefits. Fortunately, expanding communications markets and diverse new low-cost technologies offer regulators new solutions to the problems of universal service.

In my country we are focusing now on the question of how to extend communications networks to every classroom in the United States. The President, the Vice-President, Secretary of Commerce Ron Brown, Assistant Secretary of Commerce Larry Irving, Senators Hollings and Kerrey, and Congressmen Dingell and Markey are working hard to pass legislation accomplishing this goal. Extending communications networks to the classrooms will revolutionize education.

As Vice-President Gore said yesterday, I hope you here will assume the task of developing a plan to connect every school and library in the world to the Internet and ultimately to the Global Information Infrastructure.

We recognize that, to a degree, the development of the world's telecommunications networks will take place regardless of whether governments adopt appropriate policies, or make commitments to provide universal service.

The issue before us is not whether technological innovation and business investment will take place, but whether the potential for economic growth through telecommunications development can be fully realized and whether its benefits will be available to all the world's people.